WRITTEN TESTIMONY OF:

Dr. Dorota Haman, Ph.D.
Professor and Chair
Agricultural and Biological Engineering,

Institute of Food and Agricultural Sciences, University of Florida (UF/IFAS) Gainesville, Florida

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Chairman Moran, Ranking Member Blumenthal and Members of the Committee, thank you for the invitation to talk about technology in agriculture and data-driven farming. My name is Dorota Haman. I am a Professor and Chair of Agricultural and Biological Engineering Department (ABE) at the University of Florida (UF) in Gainesville, Florida.

I was educated as an agricultural engineer at Michigan State University and I have been living in Florida and working at the University of Florida since 1985. My research, teaching and extension work has been focused on water management in irrigated agriculture. Since 2007, I have been in a leadership position in Agricultural and Biological Engineering at UF and have been working with an interdisciplinary group of scientists and engineers. I have also been involved in the American Society of Agricultural and Biological Engineers (ASABE) for over 30 years, serving on various technical committees and on the Board of Trustees and I am Fellow of this organization. This testimony represents my view on the emerging, and rapidly growing area of data-driven agriculture.

Technology is rapidly changing the way we live, work and interact. This is also true in agriculture. The way we farm and produce food and fiber is experiencing a rapid change and it will only undergo more dramatic change in the near future. Agricultural operations and machinery are becoming more automated, computerized and data-driven. The future of agricultural operations will include the Internet of Things (IoT), defined as a system of interrelated computing devices, machines, robots, sensors, actuators and network connectivity. The transfer of data in this system does not require human-to-human or human-to-computer interaction.

More and more sensors are introduced every day to agricultural operations and monitoring systems. Increasingly, these sensors are connected through wireless communications to the internet, making data available in farm databases and mapping systems, and, more importantly, for enabling analysis of what affects what, why, when and how.

Many technologies that are needed to bring agricultural operations to this new level have been available for some time, but they are only now becoming economical for introduction into agriculture. The convergence of technologies in other fields is rapidly bringing down the cost of devices and sensors, and therefore making agricultural applications economically feasible. For example, sensors built as components of costly medical devices are now economical for farmers. The medical sensor may cost several hundred (if not thousands) of dollars but a simplified, maybe less accurate form, but totally adequate for the agricultural application, is becoming available for a small fraction of the price. The use of unmanned aerial vehicles (UAVs or Drones) in agricultural operations is another good example of technology becoming affordable. A drone that costs a few hundred dollars today, was sold for thousands of dollars a few years ago.

Agriculture is a major economic driver in Florida. Agricultural research and extension at the University of Florida (UF) provides knowledge, innovation and technology transfer that supports 2.2 million agriculture-related jobs and direct industry output of $148 billion in Florida (2014). Florida agriculture is very diverse and focused on specialty crops with most farms smaller and more complex than large Midwest farms dedicated to crops like soybean, corn or wheat. This diversity of production often makes introduction of new technologies more complicated for data collection and analytics. Many Agricultural Technology Providers (ATP) are focusing on agronomic crops not on specialty crops such as citrus, tomatoes, strawberries, blueberries and many other fruits and vegetables produced in Florida.

Florida is also a significant milk producer. Many modern dairy farms are highly computerized and data-driven to optimize their operation. Last week, I visited one of the dairies in North Florida. Each calf is tagged at birth and monitored throughout its entire life on the farm. Calves are fed by robots that adjust the formula of their feed based on need at their individual stage of life. The feed, health, milk production, milk quality, location etc. of every cow are monitored and available when needed. Solid waste is converted to high quality compost sold to the ornamental industry and the liquid waste is recycled through field irrigation to produce more feed for the cows. This is just a glimpse where modern agriculture is now and where it is going.

A successful peanut grower in Levy County, remotely controls center-pivot irrigation systems in response to soil moisture probe data, from anywhere in the world where there is internet, saving time and labor. Remote video systems on center-pivots allow visual monitoring for security and system operation. Enhanced GPS controlled auto-steering systems on tractors on this farm are accurate to less than an inch and virtually hands-off. They precisely map the location of planting, for precise and efficient harvesting several months later. Such precise operations eliminate over-application and overlap of pesticides and fertilizers. Soil can be sampled automatically and indexed to GPS coordinates to regulate a variable fertilizer spreader. These efficiencies save water, fertilizer and money and reduce adverse impacts on the environment.

Responding to Florida growers' needs, scientists and engineers have been focusing on research in the area of robotics, remote sensing and machine vision for many years. Early yield estimation is critical for harvest planning and marketing. Great progress has been made on estimating the yields of various specialty crops such as citrus and strawberries using autonomous vehicles and machine vision. These techniques need to be adapted to other specialty crops.

Huanglongbing (HLB) – commonly called "greening" is a devastating disease that has had significant impact on citrus yield and quality in Florida. Unfortunately, so far, no cure has been reported for HLB. The first critical step for successful control of HLB is its detection and diagnosis. It has been demonstrated that high-resolution aerial imaging using a low-cost UAV or drones can detect the disease. Recently, a vision sensor was introduced and successfully tested at UF for early detection of HLB. Since the majority of Florida citrus is already showing symptoms of the disease, research emphasis is shifting to genetic solutions to the HLB problem.

Sensor-based management of water delivery through irrigation has been implemented on many farms across the US and in Florida. Precision irrigation offers the potential for improving irrigation efficiency through localized water delivery based on plant needs, weather predictions and soil moisture sensors. Reported water savings due to sensor control of irrigation and precise application of water are on average 60%. This results in money savings to a farmer and reduced use of precious water resources.

Data-driven technologies can also improve farm safety. Wearable sensors, now under development, can save lives and reduce harm to farm workers. Alert systems that can detect personal overheating, or inform about approaching thunderstorms and lightening (typical in Florida), will also increase safety in the fields. Nine out of the 10 hottest years on record have occurred in the past decade and, according to the Centers for Disease Control and Prevention, farmworkers are more than 20 times at risk for heat-related deaths compared to other occupational groups. Wearable sensors can also alert workers to chemical exposure through direct contact during application, contact with residue on plants, or through drift from nearby applications. The wearable sensors can be also used on various machines, drones and robots to provide immediate safety intervention.

Weather data systems have been essential for efficient management of agricultural systems. A system of automatic weather stations and satellite data provide excellent management tools for Florida growers. The cost of a sophisticated blue-tooth-enabled weather station is now less than $1000. This monitoring will become more critical as climate change leads to increased changes in seasonal temperatures, rainfall patterns, and the frequency and severity of storms. For example, in the last few winters, Florida growers have been affected by insufficient chill-hours to optimize production of temperate fruits such as blueberries, peaches, and strawberries. Adapting to these changes, Florida blueberry growers are experimenting with “evergreen” production of blueberries that does not require chilling. Agriculture in Florida is not only sensitive to the manifestations of climate change mentioned above, but also to the salt water intrusions in coastal irrigation wells as a result of sea-level rise.

Data quality has always been a key issue in farm management information systems, and is more challenging in an era of Big real-time data. Intelligent processing and analytics of Big Data is challenging because of the large amount of often unstructured, heterogeneous data which requires a smart interplay between skilled data-scientists and domain experts. At present, new farm technologies and monitoring equipment are producing enormous amounts of data at a wide variety of spatial and temporal scales. Raw data sets are cumbersome and not directly useful, but become very valuable if appropriate algorithms are developed and applied. Data analytics, frequently provided by ATPs, are being developed for agricultural applications and are a necessary step to make these data valuable to growers. These processed data are also very valuable to others including insurance companies and commodity markets. A level of data standardization will be necessary for optimal sharing and utilization, including a common pool infrastructure to facilitate transfer and integration of data from different sources/companies.

New technologies are introducing new problems and issues that need careful consideration. There is no question that openness of platforms would accelerate solution development and innovation. However, data ownership, and related privacy and security issues are problems that are frequently discussed in relation to Big Data and analytics. These concerns need to be addressed, realizing that enforcement may slow down innovation.

It can be argued that access to high quality data, that allows for predictive business modeling of every aspect of farming, gives large agribusinesses advantage over farmers, especially small farmers, who do not have sufficient resources to pay for data analytics.

Leveling the playing field for smaller farmers, such as Florida farmers who produce specialty crops, through the use of open source analytics developed by public institutions such as universities and Cooperative Extension Service using public funds (e.g. USDA, NSF) is an option, providing data processing though utilities (apps), interactive models and maps.

In summary:

- Agricultural operations and machinery are becoming more automated, computerized and data-driven. It is becoming clear that the future of agricultural operations will embrace the concept of Internet of Things (IoT).

- Technology is becoming less expensive, and economical in agricultural operations. Farmers will need to adapt to be competitive.

- Farmer-collected raw data become valuable if appropriate algorithms are developed and applied. Data analytics, frequently provided by ATPs, are necessary to make data valuable to growers.

- The processing and analytics of agricultural Big Data is in its infancy, and is challenging because of the large amount of often unstructured, heterogeneous data which requires a smart interplay between skilled data-scientists and domain experts. A common pool infrastructure should be developed to enhance sharing and integration.

- Land-grant universities and Cooperative Extension Service may provide a public platform for data processing though utilities (apps), interactive models, and maps.

- Data ownership, and related privacy and security issues, are problems that are frequently discussed in relation to Big Data and analytics. These concerns need to be addressed.

I want to thank you for taking the time to focus on technological innovations in agriculture. Thank you for inviting me to testify today. I would be happy to answer any questions that you might have.